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(54) Optical modulation element and its manufacturing method

Optisches Modulationselement und sein Herstellungsverfahren

Elément de modulation optique et procédé pour sa fabrication

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(73) Proprietor: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
Kadoma-shi, Osaka-fu, 571 (JP)

(72) Inventors:
- **Wakita, Naohide**
  Osaka-shi, Osaka-fu (JP)
- **The other inventor has agreed to waive his entitlement to designation.**

(74) Representative: **Eisenführ, Speiser & Partner**
Martinistrasse 24
28195 Bremen (DE)

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- **PATENT ABSTRACTS OF JAPAN vol. 13, no. 157 (P-857)17 April 1989 & JP-A-63 316 024**

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Description

BACKGROUND OF THE INVENTION

The present invention relates to an optical modulation element for use in a display unit, etc. and its manufacturing method.

In a known ferroelectric liquid crystal panel, ferroelectric liquid crystal formed into a thin film is interposed between opposed electrodes. At this time, several limited states of the ferroelectric liquid crystal becomes stable as shown in Figs. 7a to 7c. In Figs. 7a to 7c, reference numeral 100 denotes a molecule of the ferroelectric liquid crystal, reference numeral 101 denotes a cone, reference numeral 102 denotes an upper substrate and reference numeral 103 denotes a lower substrate. In Figs. 7a and 7b, orientations of the molecules 100 of the liquid crystal are substantially uniform and spontaneous polarization of the molecules is directed upwardly or downwardly along a normal relative to the upper and lower substrates 102 and 103. In Fig. 7c, the molecules 100 of the liquid crystal are twisted in the direction of the normal relative to the upper and lower substrates 102 and 103. A direction of twist of the molecules 100 of the liquid crystal, which is opposite to that of Fig. 7c, may exist. Stable states of the molecules 100 of the liquid crystal may become different from those of Figs. 7a to 7c according to angle of inclination of the molecules 100 of the liquid crystal relative to the upper and lower substrates 102 and 103 due to the kind of the orientation film and according to bending of the liquid crystal layer but can be schematically illustrated by Figs. 7a to 7c basically.

Figs. 8a to 8c are top plan views of the liquid crystal of Figs. 7a to 7c observed from above the upper substrate 102, respectively. In Figs. 8a to 8c, reference numeral 110 denotes direction of spontaneous polarization, reference numeral 111 denotes a polarizer, reference numeral 112 denotes an analyzer, reference numeral 113 denotes a molecule of the liquid crystal in the vicinity of the upper substrate 102 and reference numeral 114 denotes a molecule of the liquid crystal in the vicinity of the lower substrate 103. When a liquid crystal panel is interposed between the polarizer 111 and the analyzer 112 intersecting at right angles, Fig. 8a corresponds to a bright state and Fig. 8b corresponds to a dark state. Thus, by using these uniform states in which the molecules 113 and 114 coincide, in position, with each other, the liquid crystal panel can give bright and dark displays. In the state of Fig. 11c in which the molecules 113 and 114 deviate from each other, the liquid crystal panel gives a gray display.

The ferroelectric liquid crystal formed into a thin film has such stable states as described above and is unstable in other states. Therefore, if a voltage applied to the liquid crystal panel is increased, changes among these states occur suddenly at specific values of the voltage. Thus, relation between voltage applied to the liquid crystal panel and quantity of light transmitted through the liquid crystal panel exhibits sharp threshold characteristics. In case a voltage not exceeding this threshold voltage is applied to the liquid crystal panel, the liquid crystal is kept stable. Hence, in the liquid crystal panel, display of high contrast and large capacity can be obtained in a simple matrix arrangement of only the electrodes without the need for providing a non-linear element at each pixel as in a thin-film transistor.

However, since the ferroelectric liquid crystal can assume a stable state restrictively as shown in Figs. 8a to 8c, it is extremely difficult to achieve a number of gradations. The state of gray display of Fig. 8c is stable only in a narrow voltage region in which the state of Fig. 11a changes to the state of Fig. 8b. Thus, it is difficult to obtain uniform intermediate gradation due to uniformity of the liquid crystal panel, etc.

Therefore, a prior art ferroelectric liquid crystal panel usually employs binary display basically so as to obtain gradation through a plurality of pixels and a plurality of scannings as proposed, for example, by T. Leroux, F. Baume et al. in 1988 INTERNATIONAL DISPLAY RESEARCH CONFERENCE, p111-113. In this method, each of a scanning electrode and a signal electrode, which constitute each pixel, is required to be provided with one drive circuit.

Meanwhile, several methods are proposed in which display of gradation is performed without increasing the number of the drive circuits. For example, in a method, liquid crystal response threshold is changed by providing a region in which thickness of a liquid crystal layer varies in one pixel as proposed by Y. Iwai et al. in Digest of 13th Liquid Crystal Conference (1987), p138-139. Meanwhile, in another method, an intermediate voltage is applied to an subelectrode by dividing a range between a voltage and an earth potential through a resistance element. Especially, regarding the latter method, a concrete example is reported in JP-A-63-316024 in which the main electrode and the subelectrode connected to a power source are connected by a resistance of 500 Ω and the subelectrode and the earth electrode are connected by a resistance of 500 Ω. However, this method has such drawbacks that power consumption is quite large and stability of liquid crystal on the subelectrode is low. This is partly because in many drive methods, positive or negative potential is applied to the sides of the scanning electrode and the signal electrode substantially at all times and thus, a rather large amount of current flows through the resistances substantially at all times. Furthermore, this may be partly because the subelectrode is grounded by the low resistance, so that drop of stability of liquid crystal on the subelectrode is greatly influenced by nonselected pulses, thereby resulting in unstable memory state.

SUMMARY OF THE INVENTION

Accordingly, an essential object of the present in-

vention is to provide an optical modulation element which is capable of displaying gradations stably by a single scanning with small power consumption without the need for increasing the number of pixels.

In order to accomplish this object, according to the present invention, there is provided an optical modulation element comprising:

- first and second substrates which confront each other;
- a liquid crystal layer which is interposed between the first and second substrates;
- a plurality of column electrodes which are provided on said first substrate;
- a plurality of n main electrodes which are provided on said second substrate;
- a plurality of n groups of m subelectrodes provided on said second substrate, each group being associated to and placed at one side of a respective main row electrode on the assumption that n denotes an integer equal or greater than 2, and that m denotes an integer equal or greater than 1,

wherein each main row electrode is connected to the closest subelectrode of the group associated to it, and each subelectrode within the group to the adjacent one by electrical elements having predetermined impedances; and

- means adapted to apply line sequential scanning signals to the main row electrodes and signals corresponding to display patterns to the column electrodes;
- characterized in that, when the m subelectrodes of a group associated to an i-th main row electrode are placed between this and a (i-1)-th one on the assumption that i denotes an integer from 1 to n, a first one of the m subelectrodes is connected to the i-th main row electrode and the m-th one is connected to the (i-1)-th main row electrode by means of electrical elements having predetermined impedances.

Further advantageous embodiments are defined in the sub-claims.

By the above described arrangement of the present invention, voltage applied to the subelectrodes is made lower than that applied to the main row electrodes through voltage division or voltage delay caused by the electrical elements. Thus, by combining response of pixels on the subelectrodes and response of pixels on the main row electrodes, clear and stable display of gradations can be performed. Meanwhile, when the number of the subelectrodes connected to each main row electrode by the electrical elements is increased, more gradations can be displayed.

Thus, in the present invention, the subelectrodes are connected to the main row electrodes by the electrical elements. Therefore, the present invention provides an optical modulation element of simple matrix type in which stable display of gradations can be performed by a single scanning with substantially no increase of power consumption without increasing the number of drive circuits.

BRIEF DESCRIPTION OF THE DRAWINGS

This object and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a top plan view of an optical modulation element according to a first embodiment of the present invention;
Fig. 1A is a fragmentary top plan view of one example of the optical modulation element of Fig. 1;
Fig. 2 is a sectional view of the optical modulation element of Fig. 1;
Figs. 3a to 3c are diagrams showing drive wave forms applied to main row electrodes in the optical modulation element of Fig. 1;
Figs. 4a to 4c are diagrams showing drive wave forms applied to column electrodes in the optical modulation element of Fig. 1;
Figs. 5a to 5f are diagrams showing voltage wave forms applied to each pixel in the optical modulation elements according to the first and second embodiment of the present invention;
Fig. 6 is a top plan view of the optical modulation element according to the second embodiment of the present invention;
Figs. 7a to 7c are schematic views showing molecules of ferroelectric liquid crystal (already referred to); and
Figs. 8a to 8c are top plan views of the molecules of ferroelectric liquid crystal of Figs. 10a to 10c, respectively (already referred to).

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout several views of the accompanying drawings.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, there is shown in Fig. 1, a liquid crystal panel 1 acting as an optical modulation element according to a first embodiment of the present invention. The liquid crystal panel 1 is constituted by an upper substrate 2, a lower substrate 3 and a liquid crystal layer interposed between the upper and lower substrates 2 and 3. Each of the upper and lower substrates 2 and 3 includes an electrically conductive thin film formed with an electrode pattern. Column electrodes X1 to X4 are provided on the upper substrate 2, while main row electrodes Y1 to Y4 and subelectrodes

SII to S41 are provided on the lower substrate 3. In this embodiment, the number n of the common electrodes is set to 4, while the number m of the subelectrodes used for each common electrode is set to 1.

If the number m is 2 or more, numerals 1, 2, 3, -- are sequentially allotted to the subelectrodes in increasing order of distance from each corresponding common electrode. For example, in the case where the number m is 3, subelectrodes Sil to Si3 ($1 \leq i \leq n$) are connected between neighboring main row electrodes Y_i and Y_{i-1} by resistors 6i1 to 6i3 and 5i as shown in Fig. 1A. Thus, the subelectrode Si1 is connected to the main row electrode Y_i by the resistor 6i1, while the subelectrode Si3 is connected to the main row electrode Y_{i-1} by the resistor 5i. Among the resistors 6il to 6i3 and 5i between the main row electrodes Y_i and Y_{i-1}, the resistor 5i connecting the subelectrode Si3 and the main row electrode Y_{i-1} has a maximum impedance.

The column electrodes X1 to X4 are connected to a signal voltage circuit by a flexible substrate 7. The main row electrodes Y1 to Y4 are connected to a scanning voltage circuit by the flexible substrate 7. Resistive patste 4 is coated linearly on the main row electrodes Y1 to Y4 and the subelectrodes S11 to S41 so as to be printed. In this case, since only portions between the main row electrodes Y1 to Y4 and the subelectrodes S11 to S41, in which the electrically conductive thin film is not present, act as resistors, these regions are, respectively, regarded as resistors 5b to 5d and 6a to 6d for convenience's sake. Each of the subelectrodes S11 to S41 is electrically connected to opposite neighboring ones of the main row electrodes Y1 to Y4 by the resistors 5b to 5d and 6a to 6d.

Fig. 2 shows the liquid crystal panel 1. An overcoat 20 for preventing dielectric breakdown is provided on the column electrodes X1 to X4 on the upper electrode 2. Likewise, an overcoat 21 for preventing dielectric breakdown is provided on the main row electrodes Y1 to Y4 on the lower substrate 3. Furthermore, alignment layers 22 and 23 formed by oblique deposition of SiO are, respectively, provided on the overcoats 20 and 21. Ferroelectric liquid crystal 24 of ester series, which exhibits chiral smetic-C phase, is interposed between the alignment layers 22 and 23.

In patterning of the electrodes in this embodiment, a distance of a gap between the main row electrode and the subelectrode for the resistors 5b to 5d and that for the resistors 6a to 6d are set to a ratio of 5 to 1 such that the resistors 5b to 5d and the resistors 6a to 6d have resistances of 10 kΩ and 2 kΩ, respectively. Meanwhile, the coated resistors are printed so as to have a fixed width. Thus, the resistors 5b to 5d having a resistance of 10 kΩ and the resistors 6a to 6d having a resistance of 2 kΩ can be obtained relatively easily. Meanwhile, even if width and thickness of the resistors are partially nonuniform, resistance value at the region changes uniformly, so that the ratio of the resistance values of 5 to 1, which determines divisional ratio of voltage, can be obtained substantially positively, thereby offering no problem for drive of the liquid crystal panel 1. In the case where transfer procedure from a film is employed in place of printing in order to form the resistors, the same excellent effects as those of printing can be achieved. Although not specifically shown, also when a method in which a resistor is coated on a flexible substrate so as to be printed or a method in which a resistor is formed on a circuit board are employed in addition to the substrates of the liquid crystal panel 1, the same effects can be obtained.

Meanwhile, the ITO electrically conductive thin film used for the electrodes for the substrates is a resistor itself. Thus, the resistors can be formed by producing an extremely thin pattern of the electrically conductive thin film simultaneously with etching a pattern of the electrodes. At this time, by controlling width and length of the electrically conductive thin film acting as the resistors, proper resistances can be imparted to the resistors and display of gradations can be performed as in the above embodiment.

The resistance value of the resistors 6a to 6d is determined by value of capacity of the liquid crystal layer and is based on such a condition that charging and discharging periods of the liquid crystal layer are sufficiently short, namely, the resistance value is sufficiently small. A limit at which influence of charging and discharging periods of the liquid crystal layer is negligible corresponds substantially to a case in which the resistors 6a to 6d assume a resistance value of 10 kΩ. In this embodiment, resistance value of the resistors 6a to 6d is set to 2 kΩ conservatively. Meanwhile, resistance value of the resistors 5b to 5d is determined by the resistance value of the resistors 6a to 6d and a desired divisional ratio of voltage. By adjusting the divisional ratio of voltage, gradations can be displayed properly. In this embodiment, the divisional ratio of voltage of 5 to 1 is optimum.

In this embodiment, 4-pulse method having quiescent phase is employed. However, this method is not necessarily essential for the present invention and thus, ordinary 4-pulse method or 2-pulse method may be employed for driving the liquid crystal panel 1 without any problem. Hereinbelow, this 4-pulse method having quiescent phase is described. Figs. 3a to 3c show examples of drive wave form applied to the common electrodes. When a scanning wave form of Fig. 3a is applied to the main row electrode Y3, writing is performed for liquid crystal on the main row electrode Y3 during a selected period t2. In this case, the wave form of Fig. 3b is applied to the main row electrode Y2 which has been selected during a period tl preceding the selected period t2. A nonselected wave form is applied to the main row electrode Y2 during the period t2. In the case where the above described voltage wave forms are applied to the main row electrodes Y3 and Y2, a wave form obtained by effecting voltage division at a ratio of 5 to 1 between the wave forms of Figs. 3a and 3b, namely the wave

form of Fig. 3c is applied to the subelectrode S31. In this case, a selected wave form of a total of 8 pulses is applied to the subelectrode S21 during the periods tl and t2. In order to drive the subelectrode S31 simultaneously with the main row electrode Y3, the selected pulse during the period t2 should have a value relatively similar to that of the main row electrodes Y2 and Y3. Also for this reason, the resistance value of the resistors 5b to 5d are required to be larger than that of the resistors 6a to 6d. Otherwise, the subelectrode S31 will be driven in dependence upon the main row electrode Y2. However, in this case, since a voltage of the selected pulse, which is low but is higher than a voltage of the nonselected pulse, is applied to the subelectrode S31 immediately after writing on the subelectrode S31, stability of writing on the subelectrode S31 deteriorates slightly. Therefore, it is desirable that the subelectrode S31 be driven in dependence upon the main row electrode Y3.

Figs. 4a to 4c show examples of voltage pulse applied to the column electrodes. The voltage pulse are required to be outputted at a number of intermediate levels corresponding to the number of the subelectrodes. In this embodiment, since one subelectrode is provided for each common electrode, achievable gradations are of 3 values in which (1) both the common electrode and the subelectrode are in the OFF state, (2) only the common electrode in the OFF state and (3) both the common electrode and the subelectrode are in the ON state. Thus, the 3-value signal is applied to the column electrodes. In Figs. 4a to 4c, liquid crystal of the column electrodes X1, X2 and X3 is in the ON state, the gray state and the OFF state, respectively. In Fig. 1, the hatched portions illustrate areas of liquid crystal in the ON state. The signal wave forms shown in Figs. 4a to 4c are, respectively, applied to the column electrodes X1 to X3, respectively. This represents a voltage modulation type drive method in which the gray wave form of Fig. 4b assumes voltage intermediate between the ON wave form of Fig. 4a and the OFF wave form of Fig. 4c. However, this voltage modulation type drive method may be replaced by a pulse width modulation type drive method.

When the drive wave forms of Figs. 3 and 4 are applied to the main row electrodes and the column electrodes, wave form applied to each pixel is determined by difference between the wave form of Fig. 3 and the wave form of Fig. 4 as shown in Figs. 5a to 5f. Figs. 5a to 5c show wave forms of voltage pulses applied between the main row electrode Y3 and each of the column electrodes X1 to X3, respectively. On the other hand, Figs. 5d to 5f show voltages applied between the subelectrode S31 and each of the column electrodes X1 to X3, respectively. In this embodiment, 4-pulse method having quiescent phase is employed in which writing pulses are constituted by 4 positive or negative pulses. In the 4 pulses, the first two pulses function to reset pixels have a fixed magnitude regardless of data to be written. Meanwhile, the last two pulses arranged to effect writing of pixels and magnitude of the last two pulses varies according to data to be written. It is well known that response of ferroelectric liquid crystal has sharp threshold characteristics. When magnitude of the last two pulses exceeds this threshold, writing of pixels is performed. In Fig. 5, the response threshold of ferroelectric liquid crystal is indicated by a voltage Vt. When writing pulse voltage exceeds the threshold Vt, the hatched regions in Fig. 1 respond and thus, 3-value display of the ON state, gray state and OFF state can be performed at pixels a, b and c, respectively.

Meanwhile, as shown by the periods tl and t2 in Figs. 5d to 5f, the writing pulse applied to liquid crystal on the subelectrode S31 is constituted by 8 pulses. Thus, as compared with a case in which liquid crystal on the subelectrodes is driven by only 4 pulses, drive margin of liquid crystal on the subelectrodes becomes wider, thereby resulting in its stable drive. However, in the 8 pulses, the first 4 pulses are influenced by the common electrodes of other stripe groups and are not essential for writing. In order to lessen this influence in this embodiment, the common electrodes are disposed, in the scanning direction, downstream of the subelectrodes which are driven in dependence upon the common electrodes, respectively. Since the pulses essential for writing are disposed at the last side of the 8 pulses, influence of the writing data signal at the time when other main row electrodes have been selected can be minimized.

Fig. 6 shows a liquid crystal panel 1' according to a second embodiment of the present invention. In the liquid crystal panel 1', the resistors 5b to 5d and 6a to 6d of the liquid crystal panel 1 are replaced by capacitors 61a to 61d and 62b to 62d. Since other constructions of the liquid crystal panel 1' are the same as those of the liquid crystal panel 1, description thereof is abbreviated for the sake of brevity. Figs. 2 to 5 apply to also the liquid crystal panel 1'. Also in the liquid crystal panel 1', the divided voltage is applied to the subelectrodes in the same manner as in the liquid crystal panel 1.

The capacitors 62b to 62d have a capacity of 1,000 pF, while the capacitors 61a to 61d have a capacity of 5,000 pF. The capacity of the capacitors 61a to 61d is determined by capacity of the liquid crystal layer. If the capacity of the capacitor 61a to 61d is small, influence of a circuit leading to a signal voltage source through the capacitors of the liquid crystal layer is increased and thus, dependence upon patterns is likely to take place. This phenomenon can be prevented on the condition that the capacitors 61a to 61d have a capacity of about 1,000 pF. In this embodiment, capacity of the capacitors 61a to 61d is set to 5,000 pF conservatively. The capacity of the capacitors 62b to 62d is determined by an inverse of the divisional ratio of voltage of 5 to 1 and the capacity of 5,000 pF of the capacitors 61a to 61d so as to assume 1,000 pF. The capacitors are formed by coating dielectric material having high dielectric constant on the overcoats 20 and 21 (Fig. 2) for preventing dielectric breakdown. This method may be replaced by a method

in which dielectric material having high dielectric constant is formed on an electrically conductive thin film on a liquid crystal substrate and further dielectric material is formed on the dielectric material, a method in which capacitors are coated on a flexible substrate so as to be printed and a method in which capacitors are formed on a circuit board. In these alternative methods, the same effects as those of the first method can be obtained.

Claims

1. An optical modulation element comprising:

   first and second substrates (2, 3) which confront each other;
   a liquid crystal layer which is interposed between the first and second substrates (2, 3);
   a plurality of column electrodes (X1-X4) which are provided on said first substrate (2);
   a plurality of n main row electrodes (Y1-Y4) which are provided on said second substrate (3);
   a plurality of n groups of m subelectrodes (S11-S41) provided on said second substrate (3), each group being associated to and placed at one side of a respective main row electrode (Y1-Y4) on the assumption that n denotes an integer equal or greater than 2, and that m denotes an integer equal or greater than 1,
   wherein each main row electrode is connected to the closest subelectrode of the group associated to it, and each subelectrode within the group to the adjacent one by electrical elements having predetermined impedances; and
   means (8, 9) adapted to apply line sequential scanning signals to the main row electrodes (Y1-Y4) and signals corresponding to display patterns to the column electrodes (X1-X4);

   characterized in that, when the m subelectrodes of a group associated to an i-th main row electrode are placed between this and a (i-1)-th one on the assumption that i denotes an integer from 1 to n, a first one of the m subelectrodes is connected to the i-th main row electrode and the m-th one is connected to the (i-1)-th main row electrode by means of electrical elements (5i, 6i1-6i3) having predetermined impedances.

2. An optical modulation element as claimed in claim 1, wherein among the electrical elements (5i, 6i1-6i3) disposed between the (i-1)-th and the i-th main row electrodes the electrical element (5i), which is disposed between the (i-1)-th main row electrode and the m-th subelectrode, has the maximum impedance.

3. An optical modulation element as claimed in claim 1, further comprising a ferroelectric liquid crystal layer (24).

4. An optical modulation element as claimed in Claim 1, wherein the electrical elements (5b-5d, 6a-6d) are means for dividing a voltage.

5. An optical modulation element as claimed in Claim 1, wherein the electrical elements (5b-5d, 6a-6d) are resistors, respectively.

6. An optical modulation element as claimed in Claim 1, wherein gaps between the main row electrodes (Y1-Y4) and neighboring ones of the subelectrodes (S11-S41) have at least two kinds of distances.

7. A method of manufacturing an optical modulation element as claimed in Claim 6, wherein the electrical elements (5b-5d, 6a-6d) are formed by printing.

8. A method of manufacturing an optical modulation element as claimed in Claim 6, wherein the electrical elements (5b-5d, 6a-6d) are formed by transfer.

9. An optical modulation element as claimed in Claim 1, wherein the electrical elements (5b-5d, 6a-6d) are capacitors (61a-61d, 62b-62d), respectively.

10. A method of manufacturing an optical modulation element as claimed in Claim 9, wherein the capacitors (61a-61d, 62b-62d) are formed by printing.

11. A method of manufacturing an optical modulation element as claimed in Claim 9, wherein the capacitors (61a-61d, 62b-62d) are formed by transfer.

12. An optical modulation element as claimed in Claim 1, wherein the electrical elements (5b-5d, 6a-6d) are formed on a substrate (3) on which the subelectrodes (S11-S41) are formed.

13. An optical modulation element as claimed in Claim 12, wherein the electrical elements (5b-5d, 6a-6d) are wholly or partially made of a material identical with that of the subelectrodes (S11-S41).

14. A method of manufacturing an optical modulation element as claimed in Claim 12, wherein the electrical elements (5b-5d, 6a-6d) are wholly or partially formed simultaneously with etching of patterns of the subelectrodes (S11-S41).

15. An optical modulation element as claimed in Claim 1, wherein the electrical elements (5b-5d, 6a-6d) are formed on a circuit board connected to the second substrate (3) on which the main row electrodes (Y1-Y4) and the subelectrodes (S11-S41) are

formed.

16. An optical modulation element as claimed in Claim 1, wherein the electrical elements (5b-5d, 6a-6d) are formed on a flexible substrate connected to the second substrate (3) on which the main row electrodes (Y1-Y4) and the subelectrodes (S11-S41) are formed.

Patentansprüche

1. Optisches Modulationselement, enthaltend:

   ein erstes sowie ein zweites Substrat (2, 3), die einander gegenüberliegen;
   eine Flüssigkristallschicht, welche zwischen dem ersten und dem zweiten Substrat (2, 3) angeordnet ist;
   mehrere Spaltenelektroden (X1-X4), die auf dem ersten Substrat (2) vorgesehen sind;
   eine Reihe von n Hauptreihenelektroden (Y1-Y4), die auf dem zweiten Substrat (3) angeordnet sind;
   eine Reihe von n Gruppen mit m Unterelektroden (S11-S41), die auf dem zweiten Substrat (3) vorgesehen sind, wobei jede Gruppe an einer Seite einer entsprechenden Hauptreihenelektrode (Y1-Y4) angeordnet und mit dieser unter der Voraussetzung verbunden ist, daß n eine ganze Zahl gleich oder größer als 2 und m eine ganze Zahl gleich oder größer als 1 ist, wobei jede Hauptreihenelektrode mit der nächstliegenden Unterelektrode der mit ihr verbundenen Gruppe und jede Unterelektrode innerhalb der Gruppe mit der benachbarten Untereleketrode durch elektrische Elemente verbunden ist, die vorbestimmte Impedanzen aufweisen; und
   Mittel (8, 9) zum Anlegen von sequentiellen Linien-Abtastsignalen an den Hauptreihenelektroden (Y1-Y4) und Signalen entsprechend den Anzeigemustern an den Spaltenelektroden (X1-X4);

   dadurch gekennzeichnet, daß, wenn die m Unterelektroden einer Gruppe, die mit der i-ten Hauptreihenelektrode verbunden ist, zwischen dieser und einer (i-1)-ten Hauptreihenelektrode unter der Voraussetzung verbunden ist, daß i eine ganze Zahl von 1 bis n bezeichnet, eine erste Unterelektrode der m Unterelektroden mit der i-ten Hauptreihenelektrode und die m-te Unterelektrode mit der (i-1)-ten Hauptreihenelektrode durch elektrische Elemente (5i, 6i1-6i3) verbunden ist, die vorbestimmte Impedanzen aufweisen.

2. Optisches Modulationselement nach Anspruch 1, bei dem unter den elektrischen Elementen (5i, 6i1-6i3), die zwischen der (i-1)-ten und der i-ten Hauptreihenelektrode angeordnet sind, das elektrische Element (5i), welches zwischen der (i-1)-ten Hauptreihenelektrode und der m-ten Unterelektrode vorgesehen ist, die maximale Impedanz aufweist.

3. Optisches Modulationselement nach Anspruch 1, weiterhin enthaltend eine ferroelektrische Flüssigkeitskristallschicht (24).

4. Optisches Modulationselement nach Anspruch 1, bei dem die elektrischen Elemente (5b-5d, 6a-6d) Mittel zum Aufteilen einer Spannung sind.

5. Optisches Modulationselement nach Anspruch 1, bei dem die elektrischen Elemente (5b-5d, 6a-6d) jeweils Widerstände sind.

6. Optisches Modulationselement nach Anspruch 1, bei dem Lücken zwischen den Hauptreihenelektroden (Y1-Y4) und den benachbarten Unterelektroden (S11-S41) der Unterelektroden (S11-S41) zumindest zwei Abstandsarten aufweisen.

7. Verfahren zum Herstellen eines optischen Modulationselements nach Anspruch 6, bei dem elektrische Elemente (5b-5d, 6a-6d) durch Drucken hergestellt werden.

8. Verfahren zum Herstellen eines optischen Modulationselements nach Anspruch 6, bei dem die elektrischen Elemente (5b-5d, 6a-6d) durch Übertragung hergestellt werden.

9. Optisches Modulationselement nach Anspruch 1, bei dem die elektrischen Elemente (5b-5d, 6a-6d) jeweils Kapazitäten (61a-61d, 62b-62d) sind.

10. Verfahren zum Herstellen eines optischen Modulationselements nach Anspruch 9, bei dem die Kapazitäten (61a-61d, 62b-62d) durch Drucken hergestellt werden.

11. Verfahren zum Herstellen eines optischen Modulationselements nach Anspruch 9, bei dem die Kapazitäten (61a-61d, 62b-62d) durch Übertragung hergestellt werden.

12. Optisches Modulationselement nach Anspruch 1, bei dem die elektrischen Elemente (5b-5d, 6a-6d) auf einem Substrat (3) erzeugt werden, auf dem die Unterelektroden (S11-S41) gebildet sind.

13. Optisches Modulationselement nach Anspruch 1 2, bei dem die elektrischen Elemente (5b-5d, 6a-6d) vollständig oder teilweise aus einem Material her-

gestellt sind, welches identisch zu dem der Unterelektroden (S11-S41) ist.

14. Verfahren zum Herstellen eines optischen Modulationselementes nach Anspruch 12, bei dem die elektrischen Elemente (5b-5d, 6a-6d) vollständig oder teilweise gleichzeitig mit dem Ätzen von Mustem auf den Unterelektroden (S11-S41) hergestellt werden.

15. Optisches Modulationselement nach Anspruch 1, bei dem die elektrischen Elemente (5b-5d, 6a-6d) auf einer Schaltungsplatine gebildet sind, die mit dem zweiten Substrat (3) verbunden ist, auf dem die Hauptreihenelektroden (Y1-Y4) und die Unterelektroden (S11-S41) gebildet sind.

16. Optisches Modulationselement nach Anspruch 1, bei dem die elektrischen Elemente (5b-5d, 6a-6d) auf einem flexiblen Substrat gebildet sind, welches mit dem zweiten Substrat (3) verbunden ist, auf dem die Hauptreihenelektroden (Y1-Y4) und die Unterelektroden (S11-S41) gebildet sind.

Revendications

1. Elément de modulation optique comprenant :

des premier et second substrats (2, 3) qui sont mutuellement en regard ;
une couche de cristaux liquides qui est interposée entre les premier et second substrats (2, 3) ;
une pluralité d'électrodes de colonne (X1 à X4) qui sont prévues sur ledit premier substrat (2) ;
une pluralité de n électrodes de rangée principales (Y1 à Y4) qui sont prévues sur ledit second substrat (3) ;
une pluralité de n groupes de m sous-électrodes (S11 à S41) prévues sur ledit second substrat (3), chaque groupe étant associé et placé sur un côté d'une électrode de rangée principale respective (Y1 à Y4) sur l'hypothèse que n représente un nombre entier égal ou supérieur à 2, et que m représente un nombre entier égal ou supérieur à 1,
dans lequel chaque électrode de rangée principale est connectée à la sous-électrode la plus proche du groupe associé à celle-ci et chaque sous-électrode à l'intérieur du groupe à l'élément adjacent par les éléments électriques ayant des impédances prédéterminées ; et
un moyen (8, 9) adapté pour appliquer des signaux de balayage de ligne séquentielle aux électrodes de rangée principales (Y1 à Y4) et des signaux correspondant aux motifs d'affichage aux électrodes de colonne (X1 à X4) ;

caractérisé en ce que, lorsque les m sous-électrodes d'un groupe associées à une ième électrode de rangée principale sont placées entre celle-ci et une (i-1)ième électrode sur l'hypothèse que i représente un nombre entier de 1 à n, une première sous-électrode des m sous-électrodes est connectée à la ième électrode de rangée principale et la mième sous-électrode est connectée à la (i-1)ième électrode de rangée principale au moyen des éléments électriques (5i, 6i1 à 6i3) présentant des impédances prédéterminées.

2. Elément de modulation optique selon la revendication 1, dans lequel parmi les éléments électriques (5i, 6i1 à 6i3) disposés entre la (i-1)ième électrode de rangée principale et la ième électrode de rangée principale, l'élément électrique (5i) qui est disposé entre la (i-1)ième électrode de rangée principale et la mième sous-électrode, présente l'impédance maximale.

3. Elément de modulation optique selon la revendication 1, comprenant de plus une couche de cristaux liquides ferroélectriques (24).

4. Elément de modulation optique selon la revendication 1, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont des moyens pour diviser une tension.

5. Elément de modulation optique selon la revendication 1, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont des résistances, respectivement.

6. Elément de modulation optique selon la revendication 1, dans lequel les intervalles entre les électrodes de rangée principales (Y1 à Y4) et les sous-électrodes voisines des sous-électrodes (S11 à S41) ont au moins deux types de distances.

7. Procédé de fabrication d'un élément de modulation optique selon la revendication 6, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont formés par impression.

8. Procédé de f) de fabrication d'un élément de modulation optique selon la revendication 6, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont formés par transfert.

9. Elément de modulation optique selon la revendication 1, dans lequel les éléments électriques 5b à 5d, 6a à 6d) sont des condensateurs (61a à 61d, 62b à 62d), respectivement.

10. Procédé de fabrication d'un élément de modulation optique selon la revendication 9, dans lequel les condensateurs (61a à 61d, 62b à 62d) sont formés

par impression.

11. Procédé de fabrication d'un élément de modulation optique selon la revendication 9, dans lequel les condensateurs (61a à 61d, 62b à 62d) sont formés par transfert.

12. Elément de modulation optique selon la revendication 1, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont formés sur un substrat (3) sur lequel les sous-électrodes (S11 à S41) sont formées.

13. Elément de modulation optique selon la revendication 12, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont totalement ou partiellement constitués d'un matériau identique à celui des sous-électrodes (S11 à S41).

14. Procédé de fabrication d'un élément de modulation optique selon la revendication 12, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont totalement ou partiellement formés simultanément avec l'attaque des motifs des sous-électrodes (S11 à S41).

15. Elément de modulation optique selon la revendication 1, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont formés sur une carte de circuit connectée au second substrat (3) sur lequel les électrodes de rangée principales (Y1 à Y4) et les sous-électrodes (S11 à S41) sont formées.

16. Elément de modulation optique selon la revendication 1, dans lequel les éléments électriques (5b à 5d, 6a à 6d) sont formés sur un substrat flexible connecté au second substrat (3) sur lequel les électrodes de rangée principales (Y1 à Y4) et les sous-électrodes (S11 à S41) sont formées.

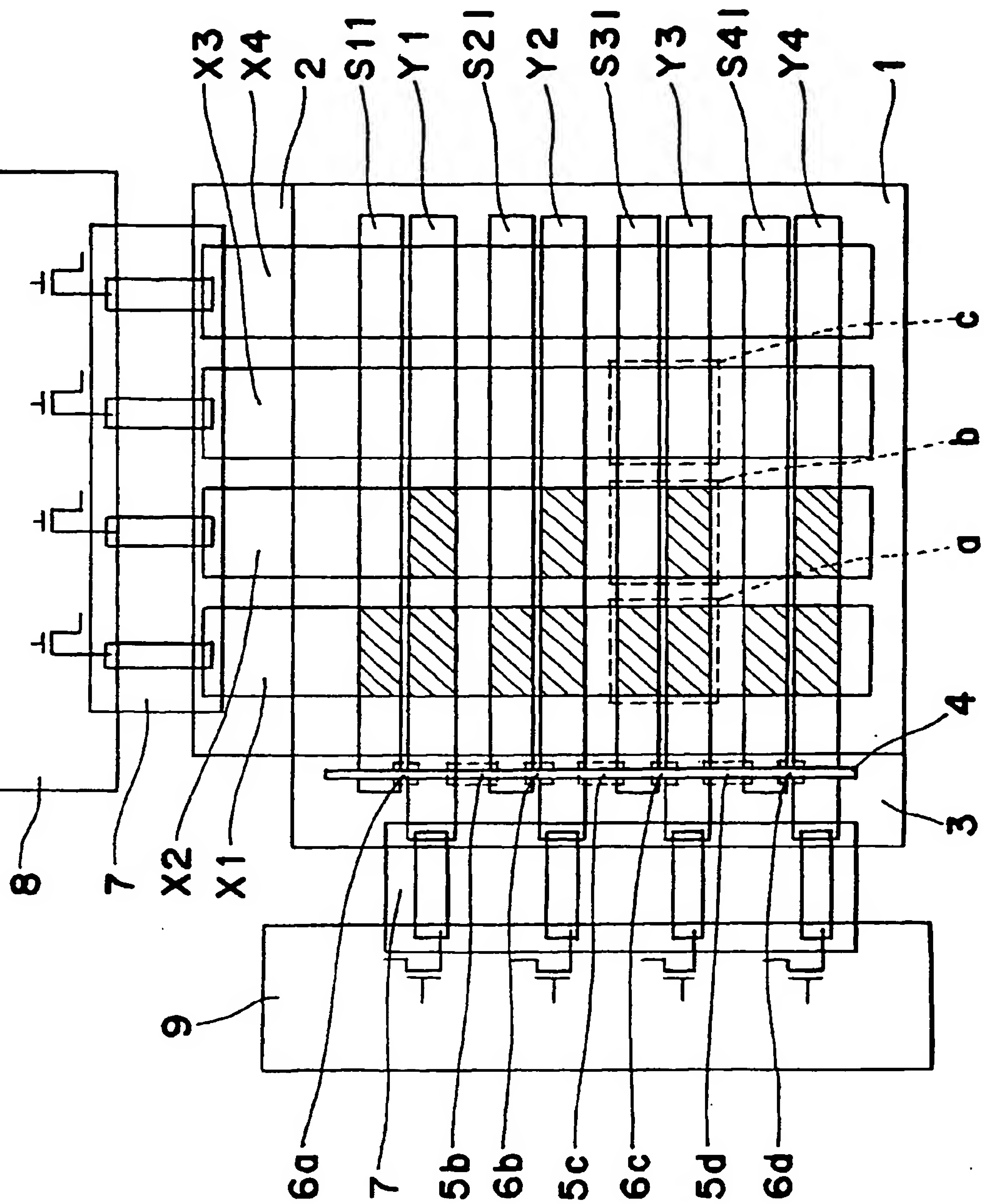
X3
X4
2
S11
Y1
S21
Y2
S31
Y3
S41
Y4
1
c
b
a
4
3
8
7
X2
X1
9
6a
7
5b
6b
5c
6c
5d
6d

Fig. 1

Fig. 1A

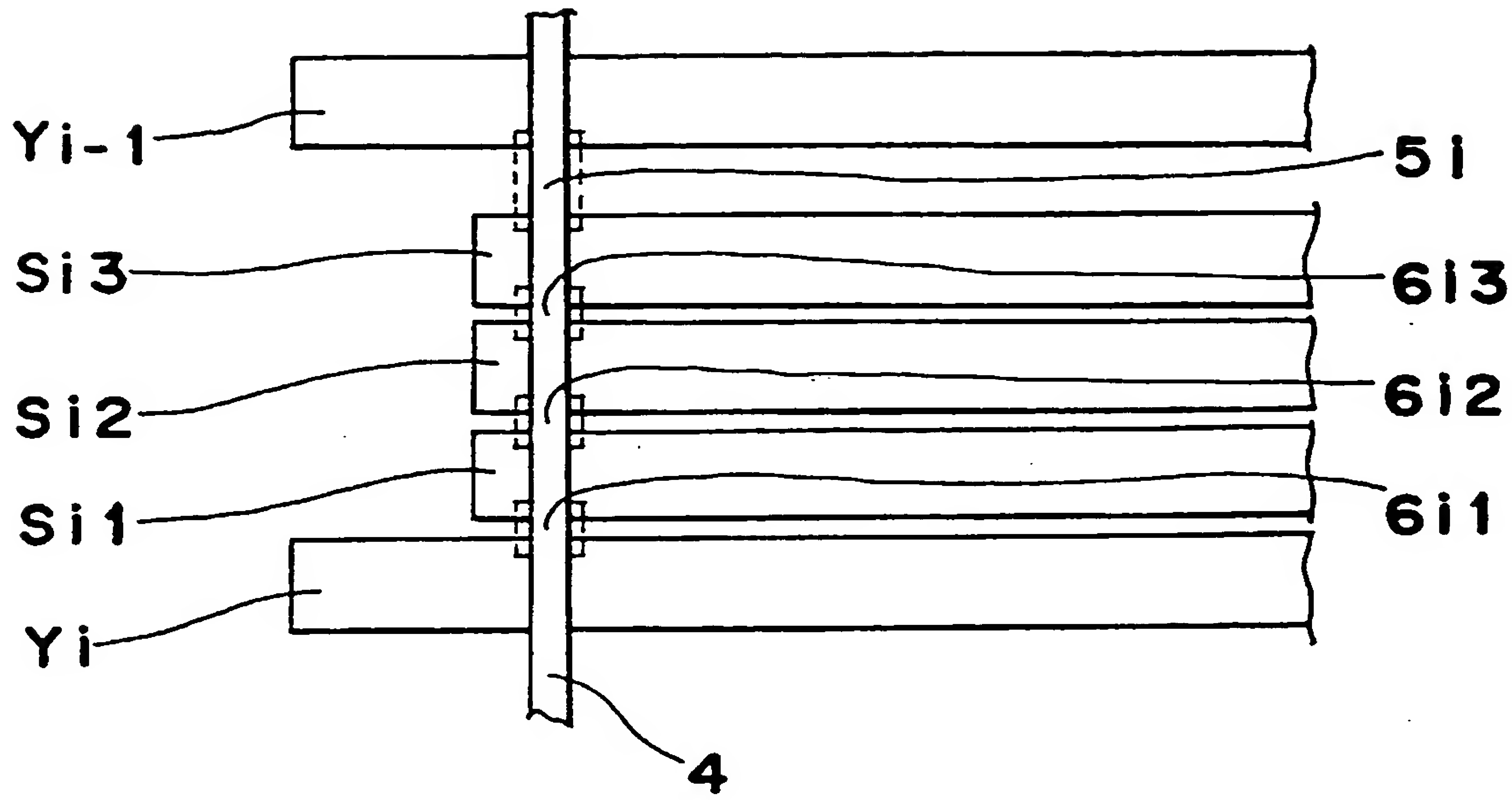
Yi-1
Si3
Si2
Si1
Yi
51
6i3
6i2
6i1
4

Fig. 2

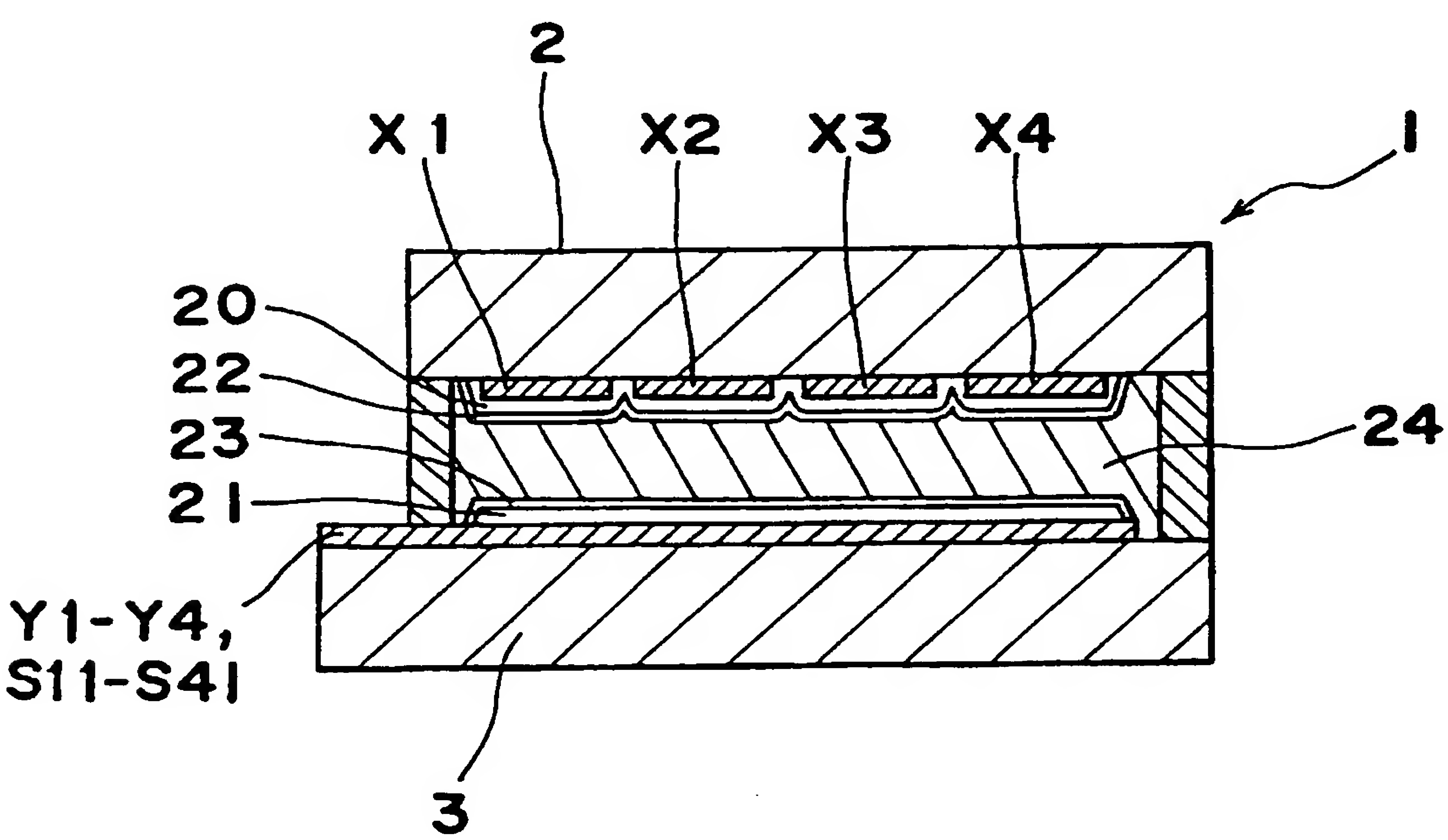
2
X1
X2
X3
X4
1
20
22
23
21
24
Y1-Y4,
S11-S41
3

Fig. 3a

Fig. 3b

Fig. 3c

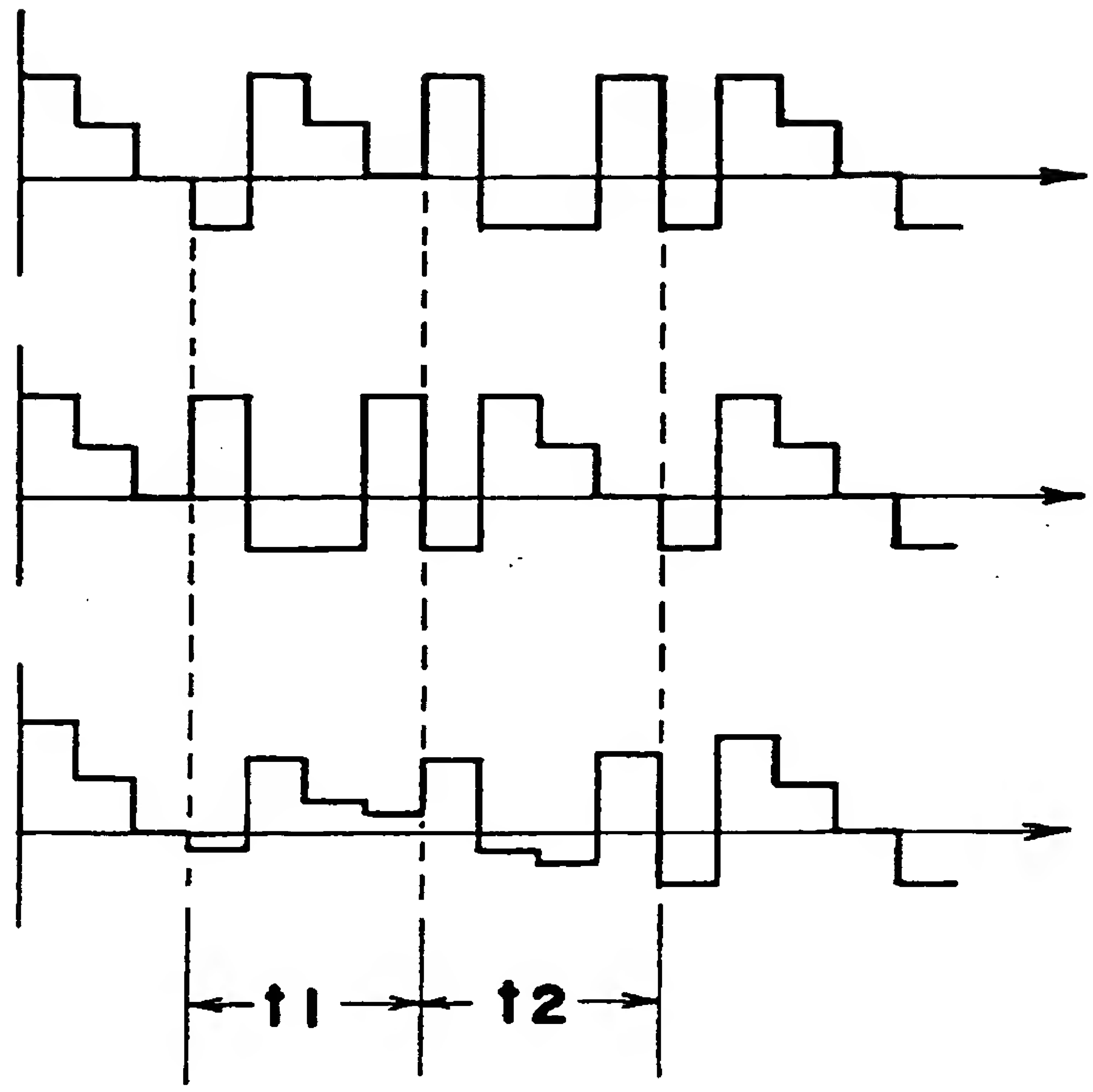

Fig. 4a

Fig. 4b

Fig. 4c

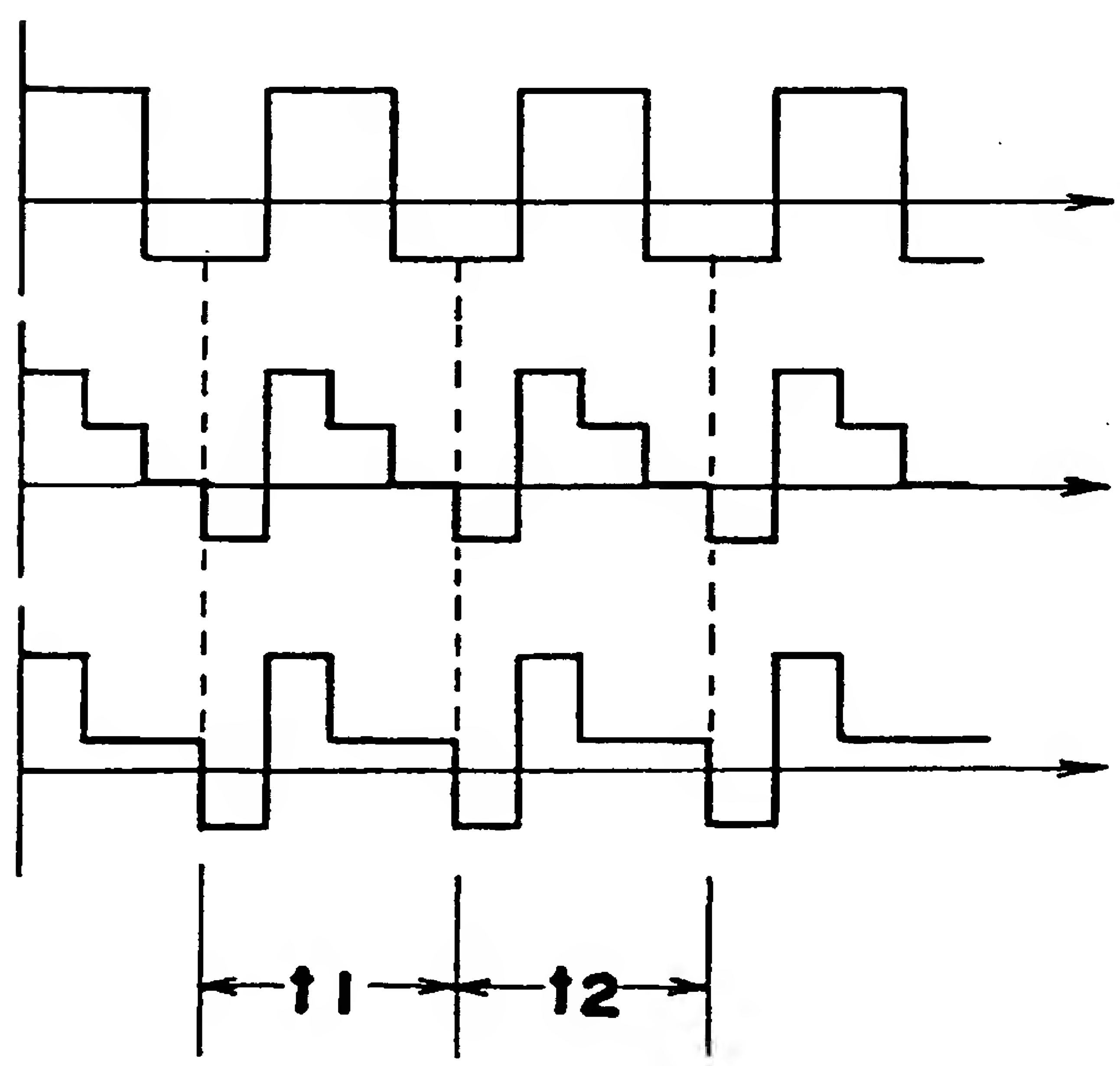

Fig. 5a

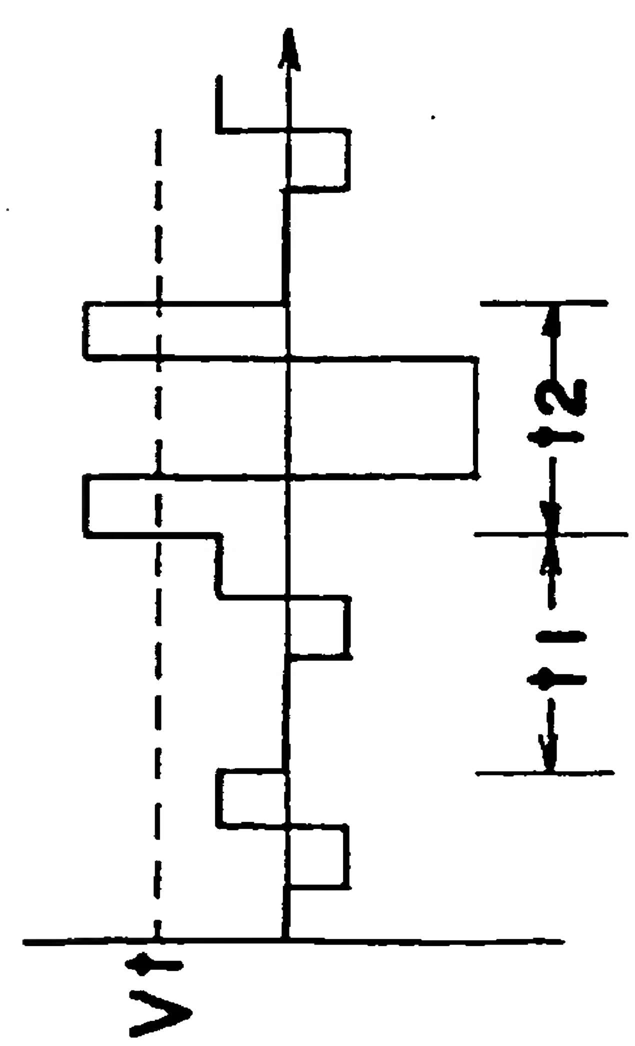

Fig. 5b

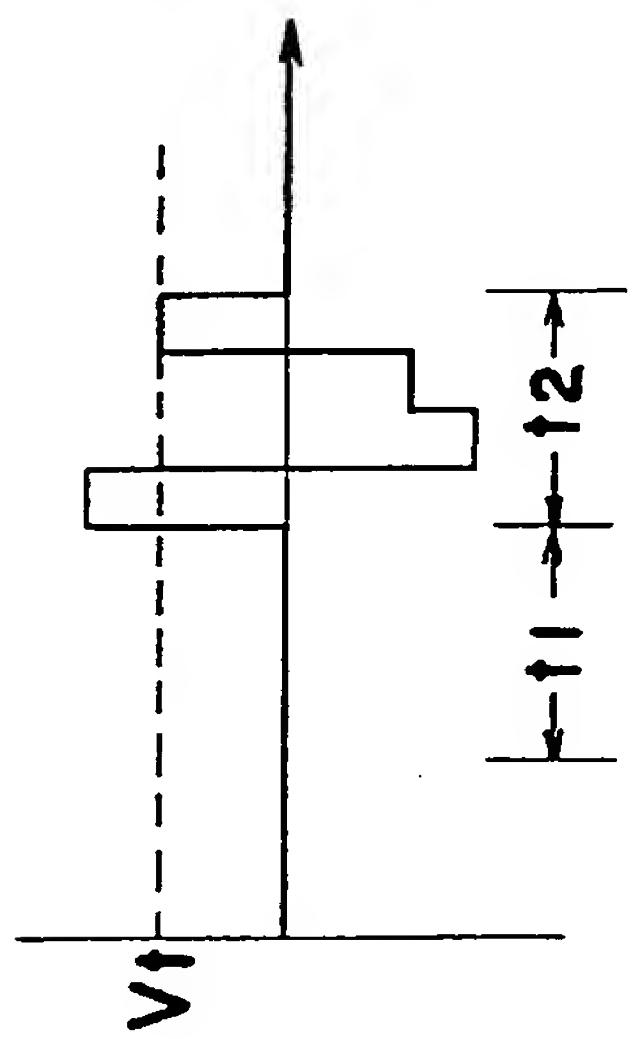

Fig. 5c

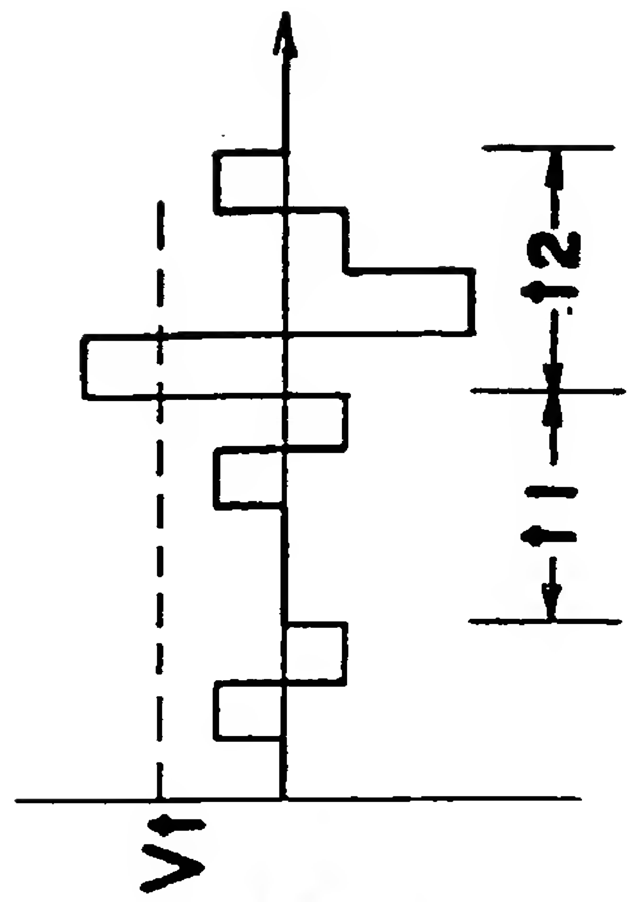

Fig. 5d

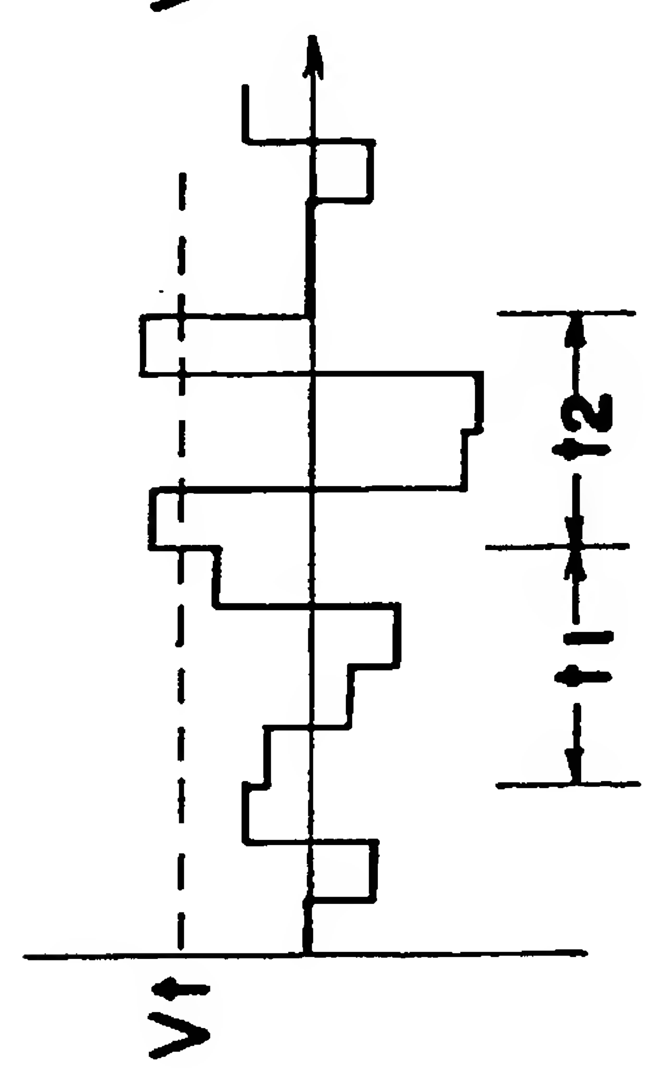

Fig. 5e

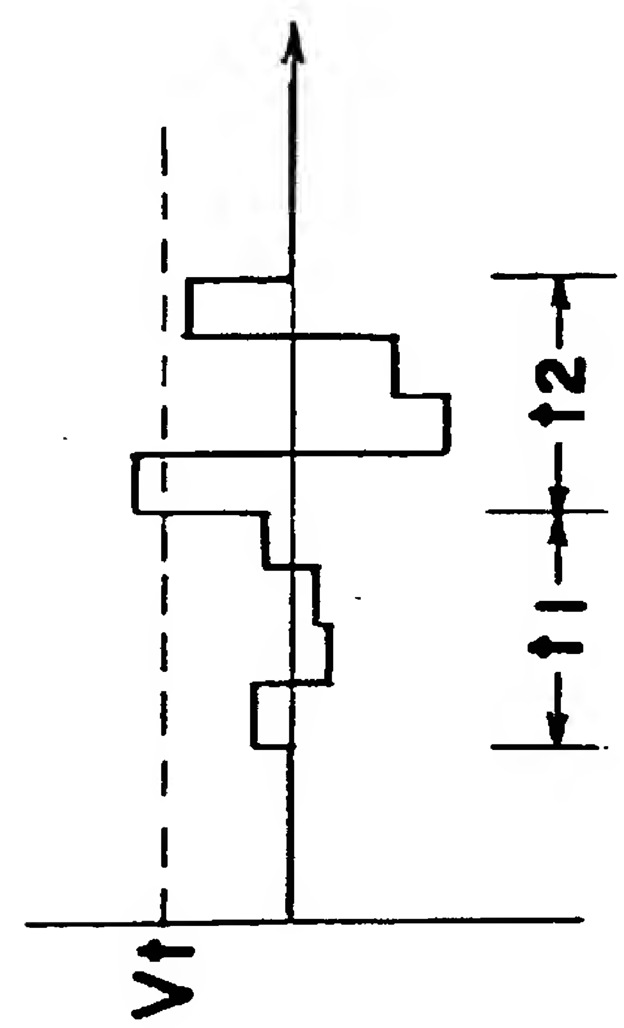

Fig. 5f

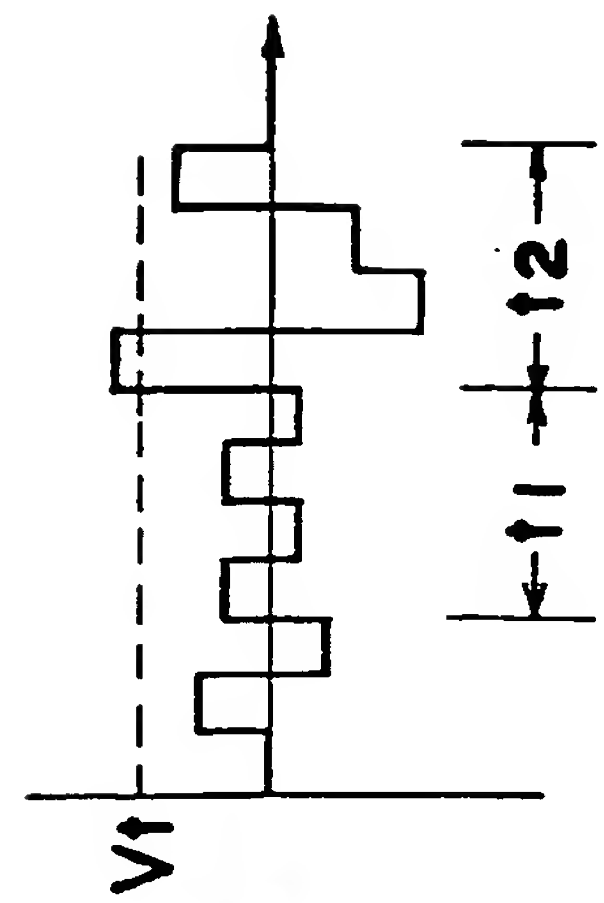

Fig. 6

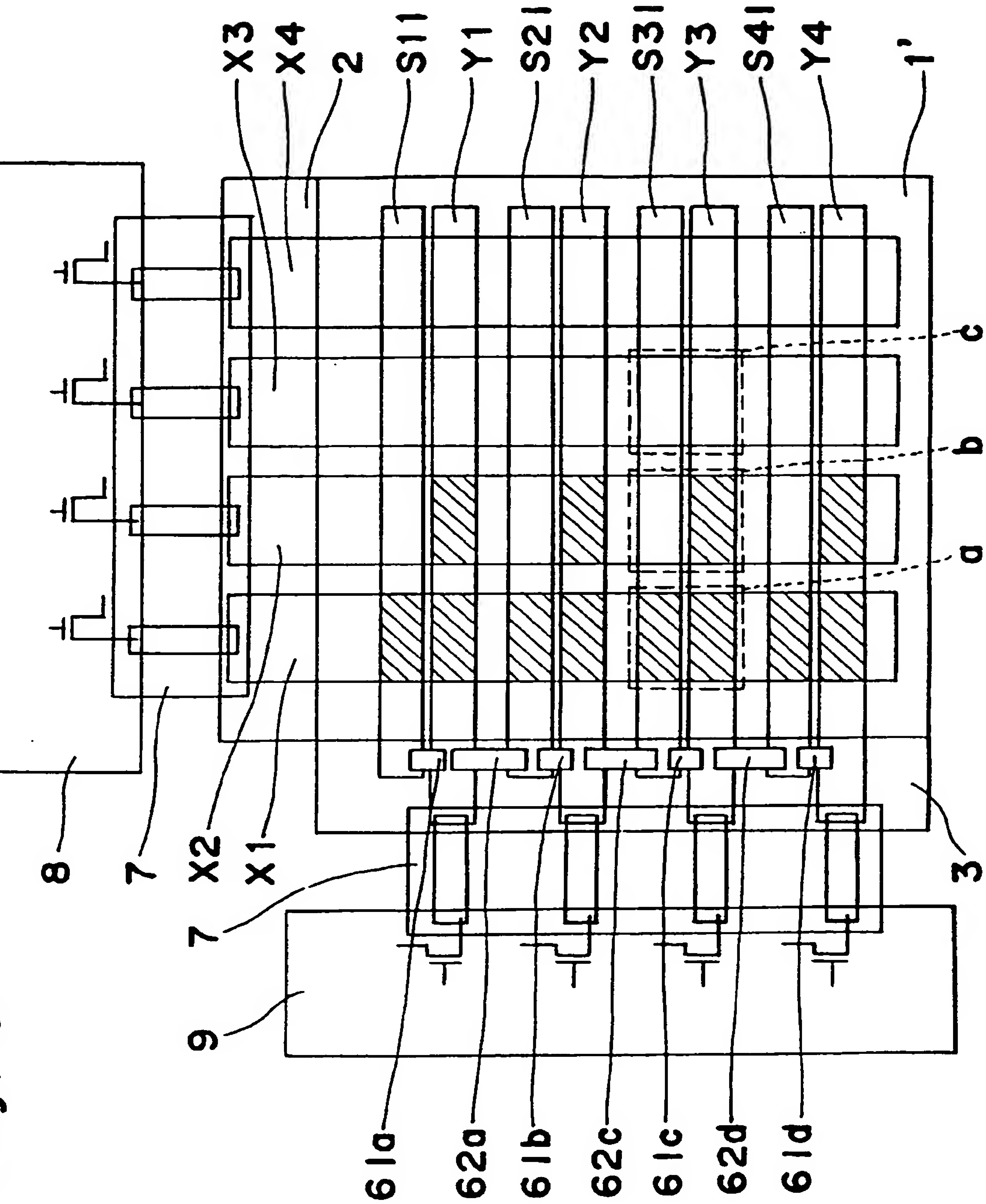
X3
X4
2
S11
Y1
S21
Y2
S31
Y3
S41
Y4
1'
c
b
a
8
7
X2
X1
7
9
3
61a
62a
61b
62c
61c
62d
61d

Fig. 7a Fig. 7b Fig. 7c

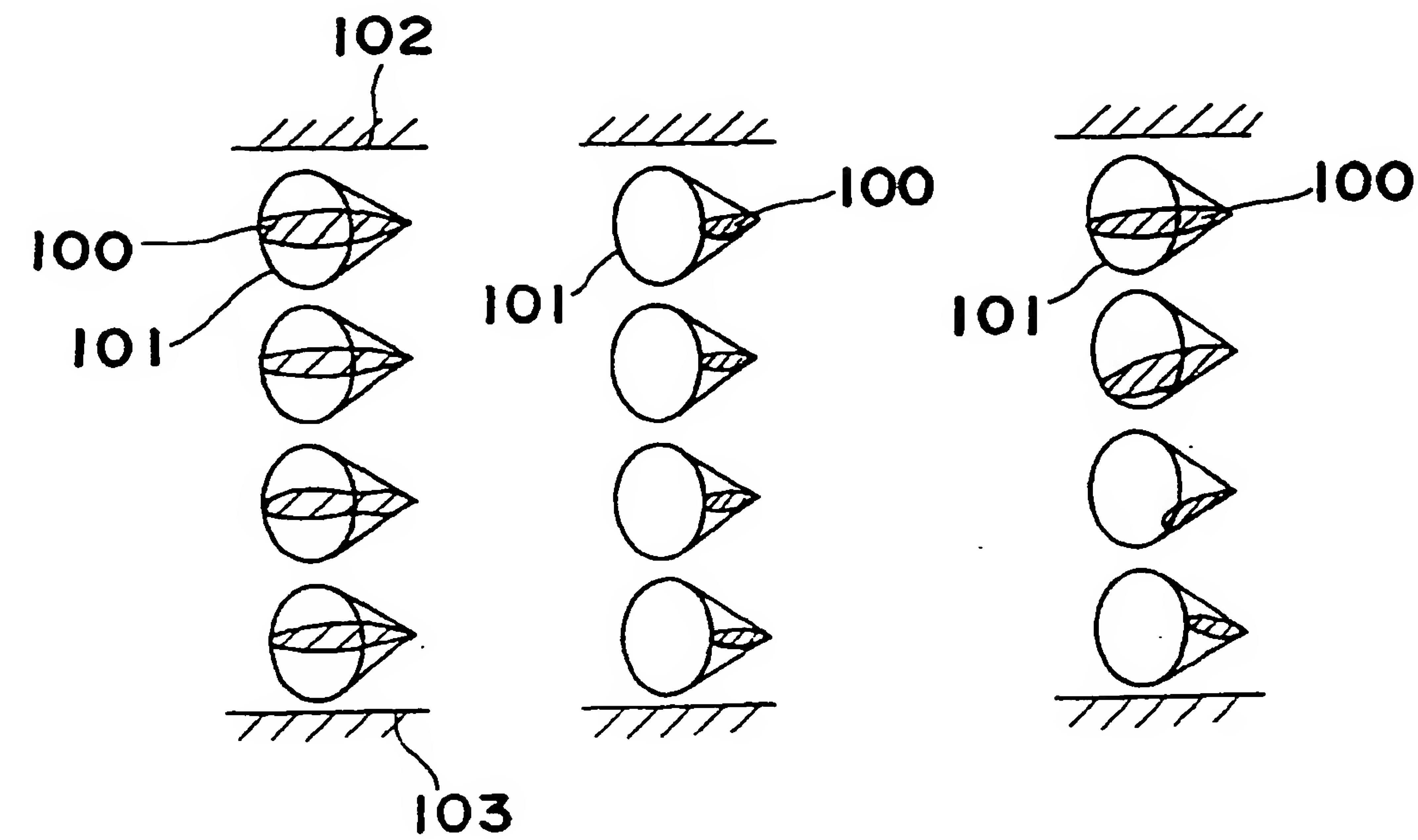

Fig. 8a Fig. 8b Fig. 8c